

A Preliminary Report on Juvenile Chinook Production in the Cowichan River, 1999

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ABSTRACT

Nagtegaal, D. A. and E. W. Carter. 2000. A preliminary report on juvenile chinook production in the Cowichan River, 1999. Can Manuscr. Rep. Fish. Aquat. Sci. 2504: 38 p.

In 1991, Fisheries and Oceans Canada (DFO), Pacific Biological Station began a study of juvenile chinook salmon (*Oncorhynchus tshawytscha*) productivity in the Cowichan River. The 1999 study is concerned primarily with the enumeration and out-migration timing of naturally-reared chinook juveniles. The estimated production of naturally-reared chinook juveniles from the 1998 brood year was 173,225 (95% CL: 85,159 – 193,718). The release of juvenile chinook from the Cowichan River hatchery totaled 2,543,109. Of these, 2,142,563 hatchery-reared chinook were released above the trapping site. Egg to fry survival for naturally-reared chinook was estimated to be 2.2% (95% CL: 1.08% - 2.47%). Trapping results maintain that most hatchery-reared chinook migrate to the Cowichan estuary within one week of release. Interaction between naturally-reared and hatchery-reared chinook juveniles is therefore believed to be limited.

RESUME

Nagtegaal, D. A. and E. W. Carter. 2000. A preliminary report on juvenile chinook production in the Cowichan River, 1999. Can Manuscr. Rep. Fish. Aquat. Sci. 2504: 38 p.

En 1991, la Station de biologie du Pacifique de Pêches et Océans Canada a entrepris une étude de la productivité des quinnats juvéniles (*Oncorhynchus tshawytscha*) dans la rivière Cowichan. L'étude de 1999 porte principalement sur le dénombrement et le moment de la dévalaison des quinnats juvéniles sauvages. On a estimé à 173 225 (niveau de confiance à 95 % : 85 159-193 718) la production de quinnats juvéniles de l'année d'éclosion 1998. L'écloserie de la Cowichan a libéré un total de 2 543 109 quinnats juvéniles, dont 2 142 563 en amont de la trappe. Dans le cas des quinnats d'écloserie, on a estimé que la survie de l'œuf jusqu'à l'état d'alevin était de 2,2 % (niveau de confiance à 95 % : 1,08 % à 2,47 %). D'après les résultats obtenus au niveau de la trappe, presque tous les quinnats d'écloserie sont descendus vers l'estuaire de la Cowichan dans la semaine qui a suivi leur libération. Il y aurait donc peu d'interaction entre les quinnats juvéniles sauvages et les quinnats d'écloserie.

INTRODUCTION

Situated in southeastern Vancouver Island, the Cowichan watershed is one of the most important salmonid producing systems draining into the Strait of Georgia (Candy et al. 1995). Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), chum (*O. keta*), steelhead (*O. mykiss*), cutthroat (*O. clarki*), as well as brown trout (*Salmo trutta*) and dolly varden (*Salmo malma*) spend periods of their life cycle or reside in this system. Historically, the chinook in this system have played an important role in the recreational, aboriginal, and commercial fisheries (Neave 1949). Since 1958 the discharge of the Cowichan River has been controlled by a weir located at the outlet of Lake Cowichan, approximately 50 km upstream from the mouth of Cowichan River (Burns et al. 1988). There have been periods of perceived salmonid population decline that have led to numerous studies (Lister et al. 1971; Candy et al. 1995; Nagtegaal et al. 1994-98).

Recent years have shown a dramatic decrease in the abundance of chinook throughout BC waters. The late 1970's were characterized by peak harvest rates of approximately 750,000 pieces. In the 1980's these rates dropped to numbers less than 25% of their former abundance (Argue et al. 1983).

For this reason, many stock rebuilding initiatives were implemented. In 1979, the Cowichan River Hatchery initiated a chinook enhancement program. Production began with a modest output of less than 70,000 chinook fry and grew to peak production of 3,000,000 smolts (Candy et al. 1996). The hatchery's 1998 brood stock collection was relatively successful. The hatchery managed to produce approximately 2,543,109 chinook smolts (D. Millerd, Cowichan River community economic development hatchery manager, P.O. Box 880, Duncan, B.C., pers. comm.).

As in previous years, a portion of these hatchery produced chinook were coded-wire tagged. Fisheries managers rely heavily on the information provided by the tagged salmonids to evaluate the strategies for each hatchery program. The data from tag recoveries also provide key information regarding stock migration, harvest rates, and a measure of enhanced contribution to the stock (Nagtegaal et al. 1998). The portion of hatchery produced chinook which were coded-wire tagged (CWT) was 726,063. However, 50,364 smolts in the Early release, 49,743 in the Late release, and 49,685 in the Hatchery release were tagged but not adipose clipped. This was done at the request of the Stock Assessment Division and the Selective Mark Fishery Committee in response to the U.S. mass marking of chinook and the proposed mark only fishery in Puget Sound/Juan de Fuca. Cowichan River chinook were chosen as one of 3 stocks (including Chilliwack and Lower Shushwap) likely to be caught in the proposed fishery and will be considered to be indicators of the impact on other Canadian stocks. Double Index tagging (DIT) will maintain DFO's ability to assess Canadian stocks, by way of pairing a group of CWT tagged chinook with adipose fins clipped (AdCWT) with a chinook group that was only CWT tagged. The ideal selective fishery would be one where there was a significant difference in exploitation rate between the AdCWT group and the CWT group, with only a small difference in survival rate.

In 1985, a chinook rebuilding strategy in conjunction with the Pacific Salmon Treaty, led to the Cowichan's inclusion into a naturally spawning chinook study. Along with the Nanaimo

and Squamish River stocks, the Cowichan River was chosen as an escapement indicator to monitor the status of Lower Strait of Georgia chinook stocks and the rebuilding of escapement into these systems (Nagtegaal et al. 1998). The accurate enumeration of chinook migrants is also an important resource management tool. For this reason the results of this ongoing study can be used to assess enhancement strategies and harvest management practices, as well as investigate possible interactions between hatchery-chinook and naturally-reared chinook.

For the purposes of this study, we refer to hatchery fish as those that were spawned and reared in the hatchery environment regardless of parental origin, and naturally-reared fish as those that spawned and reared in the river environment. The naturally-reared juvenile chinook of Cowichan River are considered to be the "ocean-type". This means that they usually migrate to sea within three months of emergence (Healey 1991). Lister et al. (1971) subdivided the Cowichan chinook migrants into two distinct groups. The 'early group' comprises the majority of the migrants and consists mainly of newly emerged fry with an average length of approximately 42 mm. The 'early group' migrates to the estuary in March and April. The 'late group' as described by Lister are larger with lengths averaging over 55 mm. This group may rear in the river system for up to 90 days before migrating to the estuary in May and June. This 'late group' may account for approximately 15% of the total juvenile chinook population.

METHODS

STUDY SITE DESCRIPTION

The Cowichan River begins at the Lake Cowichan weir and drains the mountainous slopes of the Vancouver Island range with a watershed area of 840 km² (Candy et al. 1995). Approximately 40 km north of Victoria, the Cowichan River flows eastward through the City of Duncan, and carries a mean annual discharge of 55 m³/s. Skutz Falls, located 18 km downstream of Lake Cowichan, is a partial obstruction to the upstream migration of chinook spawners (Fig. 1). In 1956 a fishway was built to help alleviate this problem (Lister et al. 1971). The Cowichan chinook spawn primarily in the mainstem, above Skutz Falls.

The rotary trap was placed at the City of Duncan old pumphouse site (Fig. 1). It was assumed that virtually all chinook spawning occurred above this point. Most of the time the trap was located at Site 7B although both sites 7A and 7B were used for this study. This area is a wider section of Cowichan River with canyon walls on one side. Between February 26 and March 17, the rotary trap was moved slightly upstream (7A) and nearer to the shore, therefore decreasing the revolutions per minute (RPM) of the trap in order to reduce damage done to trap construction as a result of high trap RPM.

FISH CAPTURE

An auger or rotary screw trap, 2.4 m in diameter was used to trap juveniles migrating downstream to the Cowichan Estuary. Fish passing through the cone were collected in a live box. In operation from February 15 to May 27, the trap was held in place by a galvanized steel cable which secured the trap at site 7B (the lower pumphouse site). The trap was set for fishing and then sampled on alternating days. The trap was set at approximately 1900 h and fished continuously until 0700 h the following morning at which time the trapped fish were removed and sampled. The trap was then set again on the following evening after sampling had occurred. During efficiency tests, trapping occurred continuously over 24 hour periods. On efficiency test days the trap was checked at both 0700 and 1900 h to monitor the day and night movement.

All fish captured were enumerated by species and recorded by time period and capture date. Chinook migrants were identified as hatchery or naturally-reared, based on identifiable physical characteristics (size, absence or presence of an adipose fin). Coho were recorded as either fry, one or two year old smolts. Biophysical conditions (water temperature, flow rates, clarity, and weather conditions) were also recorded.

ABUNDANCE ESTIMATES

Trap efficiency information, using the mark - recapture of Bismarck Brown stained juvenile fish (Ward and Verhoeven 1963), was used to expand the trap catch to estimate total numbers migrating past the trap site. Juvenile chinook and chum were stained, and then released approximately 500 m upstream from the trap site. The number of stained fish recaptured from continuous trapping over the next three to four days was recorded.

The proportion of marked fish recaptured was used to expand the unmarked fish catch and estimate the total number of fish. Mark - recapture estimates were conducted on a biweekly basis.

Trap efficiency was estimated using:

$$E_{ij} = R_{ij} / M_{ij}$$

where:

E is the estimated trap efficiency at site i and sampling week j

R is the number of marked fish recaptured.

M is the number of marked fish released.

Inherent in these efficiency tests were the following assumptions:

- i. marking of the fish does not affect short term survival of these fish,
- ii. all marked fish released above the trap site migrate downstream past the trap,

- iii. marked fish behave the same as unmarked fish, and
- iv. all recaptured fish were counted.

The total number of fish was estimated by:

$$N_i = U_i / E_i$$

where:

- N is the estimated number of marked fish.
- U is the catch of unmarked fish in the trap.

Estimates of daily fish migration were obtained by taking the mean of the days when the trap was in operation to fill in the non-fishing days. For example, when the trap was fishing on Monday and Wednesday, but not on Tuesday the mean catch for the fishing days was inserted for the non-fishing days. Twenty-four hour estimates were extrapolated for the parts of the day when the trap was not in operation. The total abundance estimate was taken from the sum of the daily catch estimates for the duration of the study (Nagtegaal et al. 1997).

The adjusted Petersen estimate (Ricker 1975) was used to obtain confidence limits of trap efficiency. Since there is added uncertainty from using biweekly trap efficiencies, interpolation of unsampled days, and extrapolation for unsampled parts of the day, the confidence limits were considered to be minimum (Nagtegaal et al. 1995; Candy et al. 1996).

GROWTH

Observations on growth for naturally-reared chinook were obtained by collecting samples from each catch of the rotary trap. Thirty chinook migrants were measured to the nearest mm fork length, and weight was recorded to the nearest one hundredth of a gram.

At the Cowichan River hatchery between 30 to 50 chinook were sampled for each rearing strategy prior to release. Sample data were available for all five hatchery releases.

RESULTS

BIOPHYSICAL CONDITIONS

During the study period the discharge of the Cowichan River decreased steadily from 105 m³/s on February 15 (with a February mean discharge of 118 m³/s) to 75.4 m³/s on May 27. The mean discharge for March was 91.7 m³/s; for April 54.1 m³/s; and for May 50.9 m³/s (Inland

Waters Directorate, unpubl.). Flow rates decreased from a high of 2.23 m/s to a low of 0.54 m/s. Water temperatures increased from 6°C to 12°C (Fig. 2).

On a regular basis, there was a build up of small organic debris in the trap. However, when this occurred there was no noticeable difference in the fishing efficiency of the rotary trap.

Water clarity at the trapping site was recorded as clear or cloudy. For the first month and a half of the study it was recorded as cloudy. From April 5 until the end of the study the water was consistently clear with five exceptions (one at the beginning of April, two near the end of April, and two near the end of May). During the time of the study there were only three days where rain was recorded (Table 1).

MIGRATION TIMING

At the pumphouse 1358 naturally-reared and 15,096 hatchery chinook juveniles were caught in the auger trap (Table 1). Downstream movement of naturally-reared chinook was observed from February 16 (6) to May 27 (5). The downstream movement of hatchery chinook was observed from March 31 (3962) to May 26 (141). It was understood that the hatchery fish released in the upper river would have reached the trapping site within approximately one week of their release date (Nagtegaal et al. 1998). Naturally-reared chinook migration peaked in the beginning of April (Fig. 3) and this was typical migration timing for the Cowichan River.

HATCHERY RELEASES

Cowichan River Hatchery had three releases 30 km above the trapping site during the study. There was no overlap in the size range between the hatchery fish and the naturally-reared fish during the first release.

Prior to the second hatchery release, the sampled size of naturally-reared fish was still less than the hatchery fish. However, with the migration of the '90-day' chinook smolts (Lister et al. 1971) there may have been some overlap in size making it difficult to distinguish larger naturally-reared fish from smaller hatchery-reared chinook, especially in the absence of adipose clips.

A total of approximately 2,142,563 hatchery-reared chinook were released above the trapping site (Table 2). Of these fish 250,447 received coded-wire tags (CWT). The early release group (approximately 899,742 fish) was released in the upper Cowichan River on March 31 at the Road pool site. The late release (529,686) occurred on May 10, at the Lake Cowichan Weir site. The lakepen release (713,135) occurred on May 5 at the Lake Cowichan Lakepen site. A hatchery release (300,618) and seapen release (99,928) occurred on May 10 and May 17, respectively. In total the rotary trap caught 87 adipose-clipped hatchery-reared fish.

TRAP EFFICIENCIES AND ABUNDANCE

At the lower pumphouse site (7B), the mean trap efficiency (Table 4) for naturally-reared chinook was calculated to be 0.23% (Fig. 4). The mean efficiency for all tests was determined to be 3.41%. At the upper pumphouse site efficiency tests were not conducted.

We estimated the total number of naturally-reared chinook migrants in Cowichan River to be 173,225 (95% CL: 85,159–193,718) and the number of hatchery-reared chinook to be 1,225,949 (95% CL: 971,172–1,589,046). Reports from the Cowichan River Hatchery indicated that a total of 2,142,563 were released above the trapping site.

DIEL MIGRATION

This year's study did not include a continuous 24-hour trapping component to determine diel migration. For this reason all assumptions of diel movement were obtained from previous studies. The only daytime trapping occurred in conjunction with the trap efficiency tests. These scanty results indicated that the majority of chinook migrants were caught in the over-night sampling, rather than the day-time hours. Additional 24-hour trapping sessions must be completed in order to obtain a more confident estimation of diel migration patterns.

GROWTH

During the study period, growth rates (mean length and weight) of naturally-reared chinook juveniles changed little until the end of April (Appendix 1). Mean length was consistently recorded at approximately 40 mm and mean weight at .45 - .55 gm. The early release hatchery fish were much larger, with a mean length of 66 mm and weight of 3.07 gm (Appendix 2). This size difference should have made them easily distinguishable from the naturally-reared chinook.

Toward the end of the study, the size of naturally-reared fish showed a length and weight increase, however, subsample sizes were much smaller than in previous sampling (N= 1 to 15). The late hatchery release fish had a mean length of 83 mm and a weight of 6.56 gm (Fig. 5). The lack of an experienced crew may have led to some chinook juveniles being incorrectly identified as hatchery or naturally-reared.

CODED-WIRE TAG RECOVERIES

During the study, 87 hatchery chinook juveniles out of the total hatchery capture (15,183) were identified as being adipose-clipped (coded-wire tagged). This number represents 0.57% of the total number of hatchery chinook caught in the trap, or .01% of the total number of coded-wire tagged hatchery releases.

DISCUSSION

ABUNDANCE ESTIMATES

Approximately 173,225 naturally-reared chinook migrated from Cowichan River in 1999 (95% CL: 85,159-193,718). This estimate did not take into consideration the migration of chinook prior to the installation of the rotary trap or after the study ended. It has been reported (Lister et al. 1971) that there is a later migration of juveniles that peaks in June.

This late migration of chinook has been observed in the Cowichan Lake coho study conducted on the Cowichan River during years prior, however, this study was not carried out in 1999. In past years, the study was conducted using a modified fyke net approximately two kilometers downstream from the Road pool in order to catch smolts.

In his report on the Cowichan River, Neave (1949) discusses a spring run of chinook that spawned primarily around the Cowichan Lake tributaries. He postulated that these spring run fish were near extinct in his time. Whether these populations of chinook are remnants of a spring run or directly related to the lake pen release strategy is unknown.

Chinook abundance estimates using the Bismarck Brown stain to calculate trap efficiency may be biased low. The assumption that stained fish have the same capture rate as unmarked migrant chinook may be untrue. The stained fish have endured more handling and stress associated with the marking process. Therefore, swimming ability and behavior of these fish may be affected and translate into lower recapture rates (Nagtegaal et al. 1997). According to Frith et al. (1995), not all released marked fish are available for recapture. Some fish are lost to predation, disease or residualization.

Water turbidity or clarity would likely affect trap avoidance by migrating chinook. Increased turbidity may decrease the ability of the migrants to avoid capture. Clarity combined with lower flow rates may have the opposite effect, increasing the ability of migrants to avoid capture. During the first month and a half of the study, the water was cloudy, this may have increased capture rates of migrating chinook. Water temperatures rose from 6°C to 12°C during the course of the study.

Flow rates during recapture periods ranged from a high of 2.23 m/s on February 22 to a low of 0.54 m/s on March 12. Flow rates remained relatively low throughout the duration of the study (between 0.50 m/s – 1.50 m/s). Low flow rates and other discharge dynamics, in combination with the cone rotation, may affect the efficiency of the trap (Frith et al. 1995).

For this study it was assumed that trap efficiencies for naturally-reared and hatchery-reared chinook were different. The efficiency information for naturally-reared chinook was obtained through Bismarck Brown efficiency tests conducted through the course of the study. For hatchery-reared chinook, data from the 1995 study were used.

Efficiency tests from other studies (Thedinga et al. 1994, Roper and Scarnecchia 1996) indicate that there are considerable differences in trap efficiencies between species, flow rates and fish size. Biophysical factors such as low flow and clarity along with the use of trap efficiencies for hatchery chinook from previous years may partially account for the low bias in this year's estimate. Wetherall (1970) submitted that higher survival rates of migrants were observed with larger fish and high flows (discharges), while fingerling in stream discharges less than 20 m³/s had lower survival rates.

Trap efficiencies may be affected by the stream characteristics in which the trap is placed. Site 7B is located in a riffle or run section of the pumphouse site, while site 7E is located in an upstream pool. Roper and Scarnecchi (1996) stated that hatchery-reared fish were often able to avoid a trap in a low velocity riffle area, however, when the trap was positioned at the head of a pool they were often caught. Since sites 7A and 7B were used for this study, the difference in trap avoidance from a low velocity riffle area and the head of a pool was not applicable to this study.

Although considerable research has focussed on understanding the physiological and genetic aspects of chinook emigration, much less information exists on the factors affecting the timing of these migrations. According to Seelbach (1985) and Roper and Scarnecchi (1996), key factors that affect hatchery fish migration timing are size and time of outplanting and water velocities. Roper and Scarnecchi (1998) compared magnitude and emigration timing of chinook juveniles in the South Umpqua River with adult escapement and four environmental factors. They determined that the magnitude of adult escapement was closely related to the magnitude of juvenile production and that lunar cycle, photoperiod and stream temperature were key factors affecting the timing of emigration.

A possible reason for the low bias is the misidentification of hatchery fish as naturally-reared fish. An inexperienced crew may account for this. It is interesting to note that on the last day of trapping (May 26), 141 hatchery-reared chinook smolts were captured, indicating that the migration of the late hatchery release (May 10) was not over.

EGG TO FRY SURVIVAL

To estimate the egg to fry survival rate, an accurate assessment of adult spawners, the percentage of females in the escapement, the average fecundity, and juvenile outmigration are needed. In 1998, the number of chinook natural spawners was estimated to be 4,371. The proportion of females was determined to be 47%, or 2,054. The average fecundity from broodstock biosample data was determined to be 3,826. With this information, the total egg production was estimated to be 7,858,604 (Fig. 6).

The estimated abundance of naturally-reared chinook fry was extrapolated to be 173,225. The egg to fry survival was therefore estimated to be 2.02% (95% CL: 1.08% - 2.47%). This estimate is comparable to survival rates from previous surveys in 1992 - 1994 (Nagtegaal et al.

1997), but is much lower than either the rates experienced in 1995-97 or the estimates of Healey (1991) who reported chinook egg to fry survivals ranging from 8% to 16%.

The differences in survival rates among years may be attributed to many factors ranging from biophysical conditions, chum escapements and spawner distribution (Nagtegaal et al. 1997). Spawner distribution in 1998 was consistent with 1994 and 1995 (most chinook spawning occurred in the middle section of the river) and low chum escapements in recent years seem to have enhanced the egg to fry survival rate (Nagtegaal et al. 1998). However, the low egg to fry survival rate in 1999 (Fig. 7), could be attributed to above average flow in both November and December of 1998. These high flows result in scouring of spawning beds and therefore loss of developing chinook fry. Montgomery et al. (1995) determined that the depth of stream bed scouring due to discharge levels was directly related to egg survival.

JUVENILE CHINOOK GROWTH

The length - weight sampling during the study showed little increase in average size of naturally-reared chinook until after April 27. Growth information obtained from April 23 to the end of the study is questionable due to smaller subsample sizes. It is unlikely that subsample sizes ranging from 1 to 15 provided accurate population representations.

According to one participant at the trapping site, the identification of naturally-reared versus hatchery chinook became more difficult after the late hatchery release since the length of naturally-reared fish had increased. It is likely that there was an overlap in fish sizes and the incorrect identification of hatchery fish as naturally-reared chinook may have occurred as a result.

JUVENILE CHINOOK INTERACTION

Some level of interaction between the early naturally-reared chinook (Lister et al. 1971) and hatchery-reared chinook in Cowichan River seems likely. Approximately 85% of the naturally-reared chinook head to the estuary upon emergence and the peak migration of these chinook occurred in early April, approximately the same time as the first hatchery release on March 31. Figure 3 shows that the first hatchery release occurred in the middle of the peak migration of naturally-reared chinook. Thus some interaction between hatchery and naturally-reared chinook migrants was highly possible.

The late hatchery release occurred on May 10. By this time the majority of 'early' chinook migrants had already passed the trapping site, and capture rates of these naturally-reared chinook had decreased substantially. Possible interactions between hatchery released chinook and the 'late' larger migrants could occur even if the hatchery fish move quickly to the estuary upon release, as Candy et al. (1996) indicated. The small numbers of hatchery fish released and the assumed small population of 'late' migrants would suggest a very limited amount of interaction.

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REFERENCES

- Argue, A. W., R. Hilborn, R. Peterman, M. Staley, and C. Walters. 1983. Strait of Georgia Chinook and Coho fishery. *Can. Bull. Fish. Aquat. Sci.* 211: 91 p.
- Burns, T., E. A. Harding, and B. D. Tutty. 1988. Cowichan River assessment (1987): the influence of river discharge on sidechannel fish habitats. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 1999.
- Candy, J. R., D. A. Nagtegaal, and B. Riddell. 1995. A preliminary report on juvenile chinook production in the Cowichan River during 1991 and 1992. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2329.
- Candy, J. R., D. A. Nagtegaal, and B. Riddell. 1996. Preliminary report on juvenile chinook production in the Cowichan river during 1993 and 1994. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2354: 80 p.
- Frith, H. R., T. C. Nelson, and C. J. Schwarz. 1995. Comparison of rotary trap mark-recapture outmigration estimates with fence counts for coho and steelhead smolts in the Keogh River, 1995. Report prepared for the British Columbia Ministry of Environment, Lands, and Parks, Watershed Restoration Program, by LGL Limited, Sidney, BC.
- Healey, M. C. 1980. Utilization of the Nanaimo River estuary by juvenile chinook (*Onchorhynchus tshawytscha*). *Fish. Bull.* 77: 653-668.
- Healey, M. C. 1982. Juvenile Pacific salmon in estuaries: the life support system. p. 315-341. *In* V. S. Kennedy (ed.) *Estuarine Comparisons*. Academic Press, New York, NY.

- Healey, M. C. 1991. Life history of chinook salmon (*Onchorhynchus tshawytscha*), p. 313-393. *In* C. Groot and L. Margolis (eds.) *Pacific Salmon Life Histories*. UBC Press, Vancouver.
- Inland Waters Directorate. Historical Stream Flow Summary, British Columbia. Water Survey Canada, Ottawa. Unpubl. Data.
- Lister, D. B., C. E. Walker, and M. A. Giles. 1971. Cowichan River chinook salmon escapements and juvenile production, 1965-1967. Department of Fisheries and Forestry, Tech. Rep. 1971-3.
- Ministry of Environment and Parks. 1986. Cowichan - Koksilah water management plan - final report. Vancouver Island Region, Water Management Branch. 2569 Kenworth Road, Nanaimo, B.C.
- Montgomery, D. R., J. M. Buffington, N. P. Peterson, D. Schuett-Hames, and T. P. Quinn. 1995. Stream-bed scour, egg burial depths, and the influence of salmonid spawning on bed surface mobility and embryo survival. *Can. J. Fish. Aquat. Sci.* 53: 1061-1070.
- Nagtegaal, D.A., P. J. Starr, and B. Riddell. 1994. A preliminary report on the chinook productivity study conducted on the Cowichan River, 1988 and 1989. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2233: 53 p.
- Nagtegaal, D. A., J. Candy, and B. Riddell. 1994. A preliminary report on the chinook productivity study conducted on the Cowichan River during 1990 and 1991. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2265: 71 p.
- Nagtegaal, D. A., J. Candy, and B. Riddell. 1994. A preliminary report on the chinook productivity study conducted on the Cowichan River during 1992. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2268: 73 p.
- Nagtegaal, D. A., J. Candy, and B. Riddell. 1995. A preliminary report on the chinook productivity study conducted on the Cowichan River during 1993. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2315: 84 p.
- Nagtegaal, D. A., G. Graf, and E. W. Carter. 1997. A preliminary report on juvenile chinook production of the Cowichan River, 1996. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2415: 84 p.
- Nagtegaal, D. A. and E. W. Carter. 1998. Adult chinook escapement assessment conducted on the Cowichan River during 1997. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2466: 53 p.
- Neave, F. 1949. Game fish populations of the Cowichan River. *Fish. Res. Bd. Can. Bull.* LXXXIV. 32 p.
- Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Res. Bd. Canada.* 191: 382 p.

- Roper, B. and D. Scarnecchi. 1996. A comparison of trap efficiencies for wild and hatchery age 0+ chinook salmon. N. Am. J. Fish. Manage. 16: 214-217.
- Roper, B. and D. Scarnecchi. 1998. Emigration of age-0 chinook salmon (*Oncorhynchus tshawytscha*) smolts from the upper South Umpqua River basin, Oregon, U.S. A. Can. J. Fish. Aquat. Sci. 56: 939-946.
- Seelbach, P.W. 1985. Smolt migration of wild and hatchery-raised coho and chinook salmon in a tributary of northern Lake Michigan. Michigan Department of Natural Resources, Fisheries Research Report 1935, Ann Arbor.
- Thedinga, J. F., M. L. Murphy, S. W. Johnson, J. M. Lorenz, and K. V. Koski. 1994. Determination of salmonid yield with rotary screw traps in the Situk River, Alaska, to predict effects of Glacial Flooding. N. Am. J. Fish. Man. 14: 837-851.
- Ward, F. J. and L. A. Verhoeven. 1963. Two biological stains as markers for sockeye salmon fry. Trans. Am. Fish. Soc. 92: 379-383.
- Wetherall, J. A. 1970. Estimation of survival rates for chinook salmon during their downstream migration on the Green River, Washington. Ph.D. Dissertation, Univ. Washington, Seattle.

Table 1. Rotary screw trap catch data at the pumphouse location, Cowichan River, 1999.

Set date (DDMM)	Site	W	Temp	Clarity	Sampling Date	Start Time	CNW	CNH	CNC	CM	COF	CO1	CO2	BB
15-02	7B	2	6C	2	16-02	7:30	6			1		2		
19-02	7B	2	6C	2	20-02	8:30	16				1	1		
26-02	7B	2	5C	2	27-02	7:40	19			8		2		
01-03	7B	2	6C	2	02-03	7:25	8			4				
03-03	7B	2	7C	2	04-03	7:20	7			9		1		
05-03	7B	1	6C	2	06-03	7:30	13			10		1		
06-03	7B	1	6C	2	09-03	7:20	28			11		2		
10-03	7B	2	7C	2	11-03	7:00	32			16		5		
12-03	7B	3	5C	2	13-03	7:15	45			23		1		
15-03	7B	1	4C	2	16-03	7:15	26			33	1	1		
17-03	7B	1	5C	2	18-03	7:15	115			222	20	25		
19-03	7B	1	6C	2	20-03	7:15	78			525	33	28		
22-03	7B	2	6C	2	23-03	8:00	67			1230	2	14		
24-03	7B	1	6C	2	25-03	7:15	45			1048	13	24	3	
26-03	7B	1	7C	2	27-03	7:15	45			1095	2	13	1	
29-03	7B	1	7C	2	30-03	7:15	59			1352	16	6	2	6 CM
29-03	7B	2	7C	2	30-03	19:15	32			261	2	2		
30-03	7B	2	7C	2	31-03	7:15	75			2086	14	4	1	
31-03	7B	1	8C	2	31-03	19:15	10	3962		310	1			
02-04	7B	1	8C	2	03-04	7:15	70	600	12	3094	48	17		
05-04	7B	1	9C	1	06-04	7:30	127	99		5481	86	14		
07-04	7B	2	8C	2	08-04	7:15	63	19		8817	43	12		
12-04	7B	1	9C	1	13-04	7:15	87	28		16538	224	34		
14-04	7B	1	10C	1	15-04	19:15	30	13		12260	122	21		2 CNW; 9 CM
15-04	7B	1	10C	1	15-04	7:15		1		347	6	5		
16-04	7B	1	10C	1	16-04	19:15	2			429				
19-04	7B	1	10C	1	17-04	19:15	25	5		9285	79	21		
21-04	7B	3	9C	1	20-04	19:15	45	18		4929	356	51		
23-04	7B	1	9C	2	22-04	7:15	42	19		5597	359	63		
26-04	7B	1	11C	1	24-04	19:10	12	10		3156	86	38		
28-04	7B	1	10C	1	27-04	19:15	9	7		1790	89	70		
29-04	7B	1	10C	2	29-04	19:30	3	6		1040	38	71		
29-04	7B	1	11C	1	29-04	7:15				53	1	2		
30-04	7B	1	11C	1	30-04	7:15	3	8		955	24			13 CM
30-04	7B	1	11C	1	01-05	7:15	5	2		1063	31	25		
03-05	7B	1	11C	1	04-05	7:15	16	6	1	2154	356	94		
05-05	7B	2	11C	1	06-05	7:15	4	5		750	238	76		
07-05	7B	2	10C	1	08-05	7:00	4	3061	30	943	334	56		
10-05	7B	1	11C	1	11-05	7:15	9	2350		351	107	3		
12-05	7B	1	11C	1	13-05	7:15	17	1901		388	222	9		
14-05	7B	1	11C	1	15-05	7:15	12	288		360	227	1		
17-05	7B	3	11C	1	18-05	7:15	26	956	3	994	361	5		

Table 1 (cont'd)

Set date (DDMM)	Site	W	Temp	Clarity	Sampling Date	Start Time	CNW	CNH	CNC	CM	COF	CO1	CO2	BB
19-05	7B	2	11C	1	20-05	7:00	5	868	22	287	179	16		
21-05	7B	1	11C	2	22-05	7:00	11	723	19	137	143	15		
25-05	7B	1	12C	2	27-05	7:00	5	141		83	147	11		
TOTAL:							1358	15096	87	89525	4011	862	7	

Legend:

CC - sculpin
 CM - chum
 CNC - chinook adipose clip
 CNH - chinook hatchery
 CNW - chinook, wild
 CO1 - coho smolt
 CO2 - coho 2yr old
 COF - coho fry
 CT - cutthroat
 LL - lamprey
 P - perch
 RB - rainbow trout
 SB - stickleback
 SK - sockeye
 ST - steelhead
 STH - steelhead, hatchery
 STW - steelhead, wild

Clarity - 1 Clear
 2 Cloudy

Weather - 1 Clear
 2 Cloudy
 3 Raining

Temp - Water temperature

Table 2. Cowichan hatchery chinook release data, 1999.

Release Code	Total Released	Tag Code	CWT Tagged	% Tagged	Release Date	Length (mm)			Weight (gm)			Condition Coefficient
						Mean	Min	Max	Mean	Min	Max	
EARLY	899742	18-37-28 18-37-29 18-31-07 18-31-08	100658 25147 25147 25182 25182	11%	31-Mar-99	66.66	56	77	3.07	1.40	5.02	1.04
Lakepen	713135	18-37-26 18-37-27	50271 25136 25135	7%	5-May-99	80.76	65	91	5.93	2.92	8.66	1.11
Late	529696	18-37-30 18-37-31 18-31-09 18-31-10	99518 24898 24887 24872	19%	10-May-99	83.88	69	108	6.56	2.84	14.26	1.11
Hatchery	300618	18-37-32 18-37-33 18-31-11 18-31-12	100021 25168 25168 24843	33%	10-May-99	83.82	71	98	6.31	3.19	9.90	1.07
Seapen	99928	18-37-34	25127 25127	25%	17-May-99	77.24	67	93	5.10	2.73	9.24	1.11
Total	2543109		726063	29%								
Total Released above Trap Site:				2142563								

Release Sites:

- Early- upper Cowichan R. (Road Pool)*
- Lakepen- Lake Cowichan above the weir (Lakepen site)*
- Late- upper Cowichan R. (below weir)*
- Hatchery- released directly from Hatchery
- Seapen- released from seapens in Cowichan Bay

* indicates that these fish are released above trapping site

Table 3. Expanded daily trap catch estimates at the Cowichan River pumphouse site, 1999.

Naturally reared					
Date	Observed	Missing cells Interpolated	24-hour Estimates	Extrapolated Estimates	Cumulative Total
16-Feb	6		7	242	242
17-Feb		11	12	443	685
18-Feb		11	12	443	1128
19-Feb		11	12	443	1571
20-Feb	16		18	644	2215
21-Feb		17	19	685	2900
22-Feb		17	19	685	3584
23-Feb		17	19	685	4269
24-Feb		17	19	685	4954
25-Feb		17	19	685	5639
26-Feb		17	19	685	6323
27-Feb	19		21	765	7088
28-Feb		13	15	524	7612
01-Mar		13	15	524	8136
02-Mar	8		9	322	8458
03-Mar		7	8	282	8740
04-Mar	7		8	282	9022
05-Mar		10	11	403	9424
06-Mar	13		15	524	9948
07-Mar		20	22	806	10753
08-Mar		20	22	806	11559
09-Mar	28		31	1128	12687
10-Mar		30	34	1208	13895
11-Mar	32		36	1289	15184
12-Mar		38	43	1530	16714
13-Mar	45		50	1812	18527
14-Mar		35	39	1410	19936
15-Mar		35	39	1410	21346
16-Mar	26		29	1047	22393
17-Mar		70	78	2819	25212
18-Mar	115		129	4632	29844
19-Mar		96	108	3866	33710
20-Mar	78		87	3141	36852
21-Mar		72	81	2900	39752
22-Mar		72	81	2900	42651
23-Mar	67		75	2698	45350
24-Mar		56	63	2255	47605
25-Mar	45		50	1812	49418
26-Mar		45	50	1812	51230
27-Mar	45		50	1812	53042
28-Mar		68	76	2739	55781
29-Mar		68	76	2739	58520
30-Mar	91		102	3665	62185
31-Mar	85		95	3423	65608
01-Apr		77	86	3101	68709
02-Apr		77	86	3101	71811
03-Apr	70		78	2819	74630
04-Apr		98	110	3947	78577

Table 3 (cont'd)

Date	Observed	Missing cells Interpolated	24-hour Estimates	Extrapolated Estimates	Cumulative Total
05-Apr		98	110	3947	82524
06-Apr	127		142	5115	87639
07-Apr		95	106	3826	91465
08-Apr	63		71	2537	94002
09-Apr		75	84	3021	97023
10-Apr		75	84	3021	100044
11-Apr		75	84	4200	104244
12-Apr		75	84	4200	108444
13-Apr	87		97	4872	113316
14-Apr		59	66	3304	116620
15-Apr	32		36	1792	118412
16-Apr		28	31	1568	119980
17-Apr	25		28	1400	121380
18-Apr		35	39	1960	123340
19-Apr		35	39	1960	125300
20-Apr	45		50	2520	127820
21-Apr		43	48	2408	130228
22-Apr	42		47	2352	132580
23-Apr		27	30	1512	134092
24-Apr	12		13	672	134764
25-Apr		10	11	560	135324
26-Apr		10	11	560	135884
27-Apr	9		10	504	136388
28-Apr		5	6	280	136668
29-Apr	3		3	168	136836
30-Apr	3		3	168	137004
01-May	5		6	280	137284
02-May		10	11	560	137844
03-May		10	11	560	138404
04-May	16		18	896	139300
05-May		10	11	560	139860
06-May	4		4	224	140084
07-May		4	4	224	140308
08-May	4		4	224	140532
09-May		6	7	336	140868
10-May		6	7	336	141204
11-May	9		10	504	141708
12-May		13	15	431	142138
13-May	17		19	563	142701
14-May		15	17	497	143198
15-May	12		13	398	143596
16-May		19	21	629	144225
17-May		19	21	629	144855
18-May	26		29	861	145716
19-May		15	17	497	146213
20-May	5		6	166	146379
21-May		8	9	265	146644
22-May	11		12	364	147008
23-May		8	9	265	147273

Table 3 (cont'd)

Date	Observed	Missing cells Interpolated	24-hour Estimates	Extrapolated Estimates	Cumulative Total
24-May		8	9	265	147538
25-May		8	9	265	147803
26-May		8	9	265	148068
Total:	1317			148234	

Table 3 (cont'd)

Hatchery-reared:

Date	Observed	Missing cells Interpolated	24-hour Estimates	Extrapolated Estimates	Cumulative Total
30-Mar			0	0	0
31-Mar	3962		4199	194405	0
01-Apr		2281	2417	111923	0
02-Apr		2281	2417	111923	0
03-Apr	600		636	29440	29440
04-Apr		349	369	17125	46565
05-Apr		349	369	17125	63689
06-Apr	99		104	4858	68547
07-Apr		59	62	2895	71442
08-Apr	19		20	932	72374
09-Apr		23	24	1129	73503
10-Apr		23	24	1129	74631
11-Apr		23	24	1129	75760
12-Apr		23	24	1129	76888
13-Apr	28		29	1374	78262
14-Apr		21	22	1030	79292
15-Apr	14		14	687	79979
16-Apr		9	9	442	80421
17-Apr	5		5	245	80666
18-Apr		12	12	589	81255
19-Apr		12	12	589	81844
20-Apr	18		19	883	82727
21-Apr		18	19	883	83610
22-Apr	19		20	932	84543
23-Apr		14	14	687	85230
24-Apr	10		10	491	85720
25-Apr		8	8	393	86113
26-Apr		8	8	393	86505
27-Apr	7		7	343	86849
28-Apr		6	6	294	87143
29-Apr	6		6	294	87438
30-Apr	8		8	393	87830
01-May	2		2	98	87928
02-May		4	4	196	88125
03-May		4	4	196	88321
04-May	6		6	294	88615
05-May		5	5	245	88861
06-May	5		5	245	89106
07-May		5	5	245	89351
08-May	3061		3244	150195	239547
09-May		2705	2867	132727	372274
10-May		2705	2867	132727	505001
11-May	2350		2491	115308	620310
12-May		2125	2252	104268	724578
13-May	1901		2015	93277	817855
14-May		1094	1159	53680	871535
15-May	288		305	14131	885666
16-May		622	659	30520	916186

Table 3 (cont'd)

Date	Observed	Missing cells Interpolated	24-hour Estimates	Extrapolated Estimates	Cumulative Total
17-May		622	659	30520	946706
18-May	956		1013	46908	993614
19-May		912	966	44749	1038364
20-May	868		920	42591	1080954
21-May		795	842	39009	1119963
22-May	723		766	35476	1155439
23-May		432	457	21197	1176636
24-May		432	457	21197	1197833
25-May		432	457	21197	1219030
26-May	141		149	6919	1225949
Total:	11134		26484	1225949	

Table 4. Trap efficiency data, pumphouse site, Cowichan River, 1999.

Pumphouse Site:

Date	Flow	Released			Recovered			% Recovered	
		Chinook	Chum	Coho	Chinook	Chum	Coho	Chin/Chum	Expansion factor
29-Mar	10428	41	261	1		6		1.98%	50.50
14-Apr	11295	81	206		2	9		3.83%	26.09
29-Apr	18999		284	5		13		4.50%	22.23
Total:		122	751	6	2	28		3.41%	29.30
					Chinook only:			0.23%	61.00

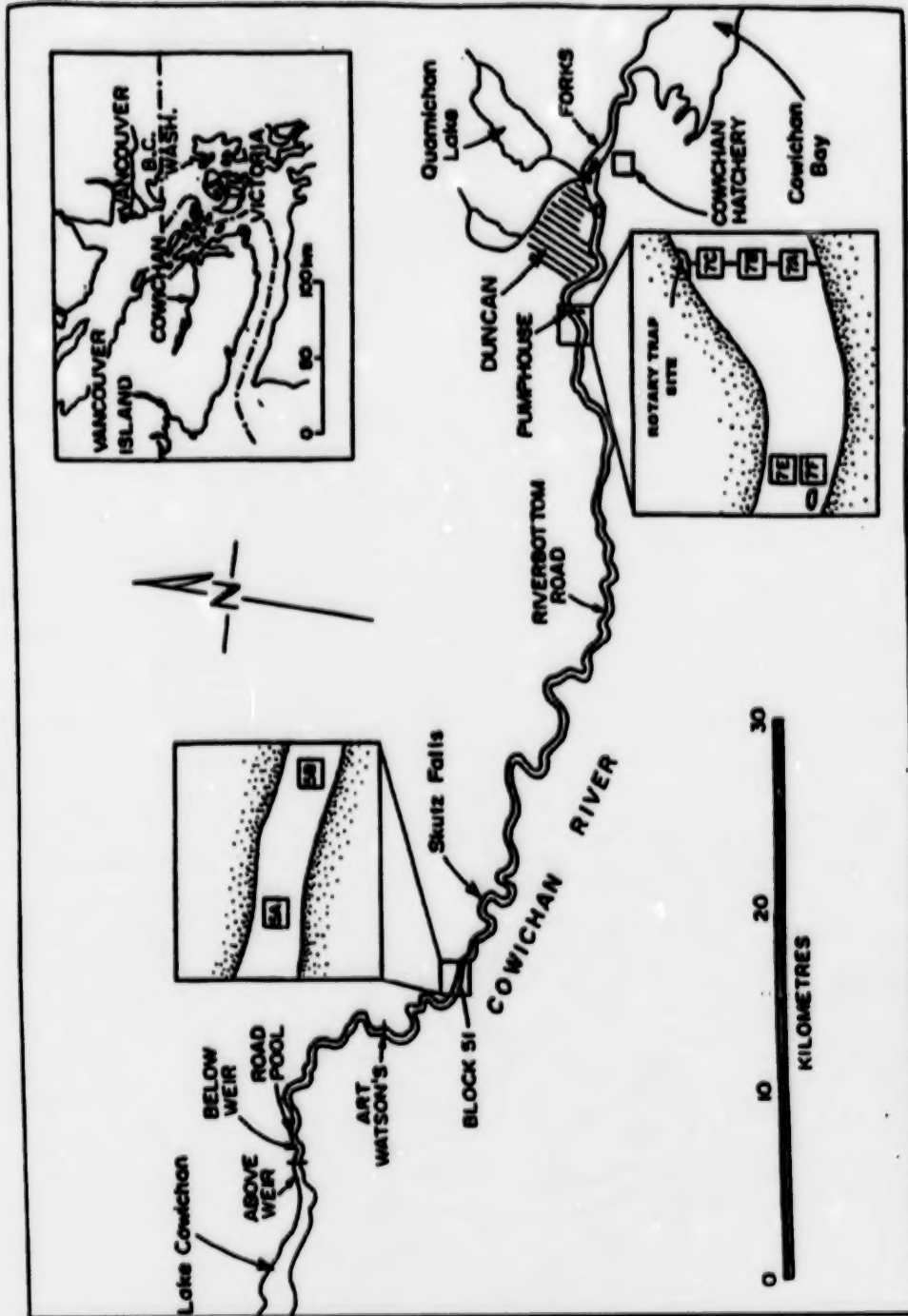


Fig 1. Cowichan River downstream fry trap locations.

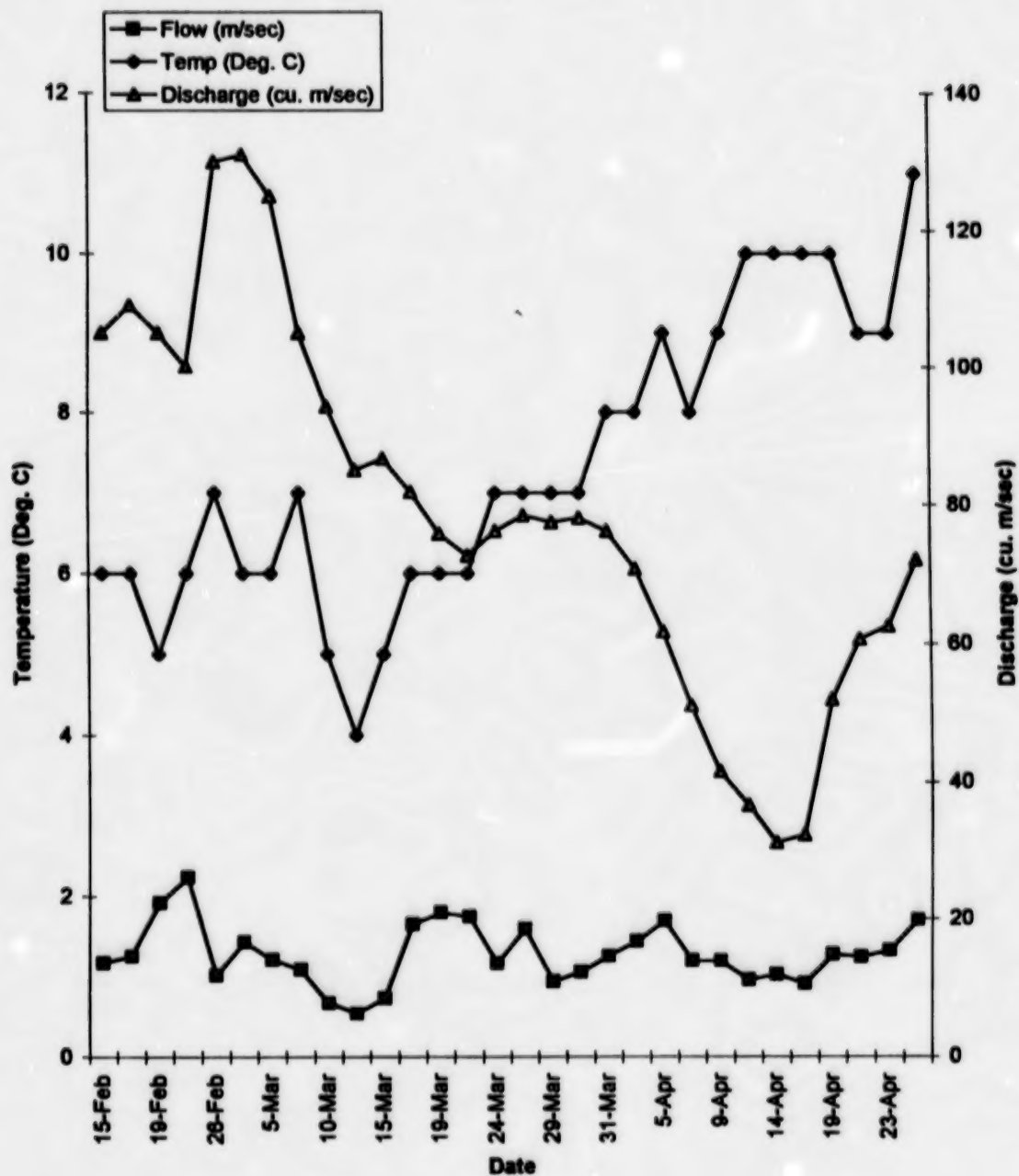


Fig. 2. Biophysical conditions recorded at the pumphouse site, Cowichan River, 1999.

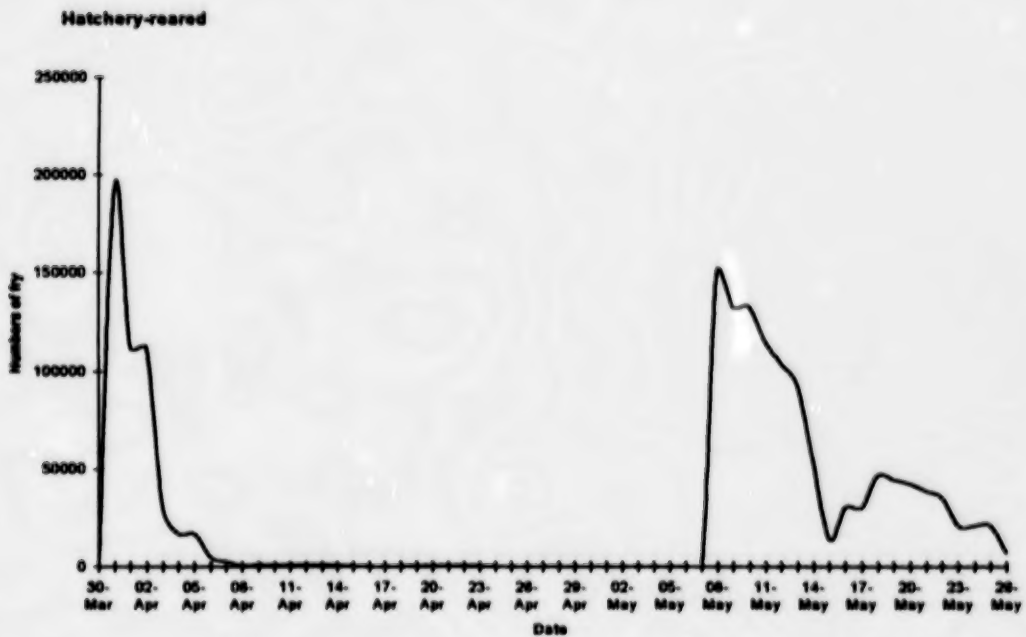
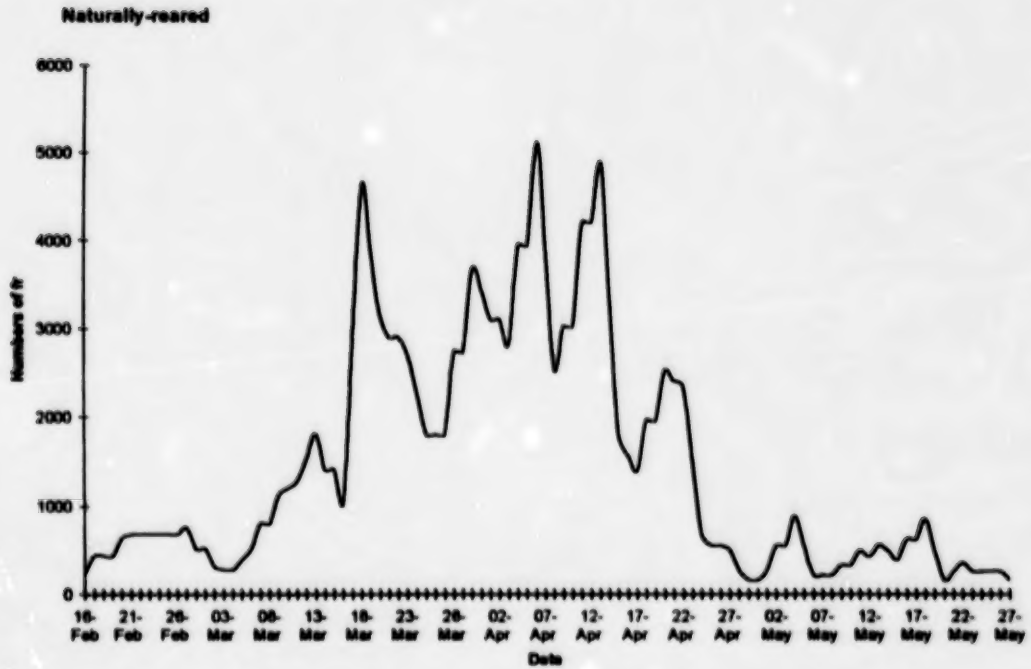
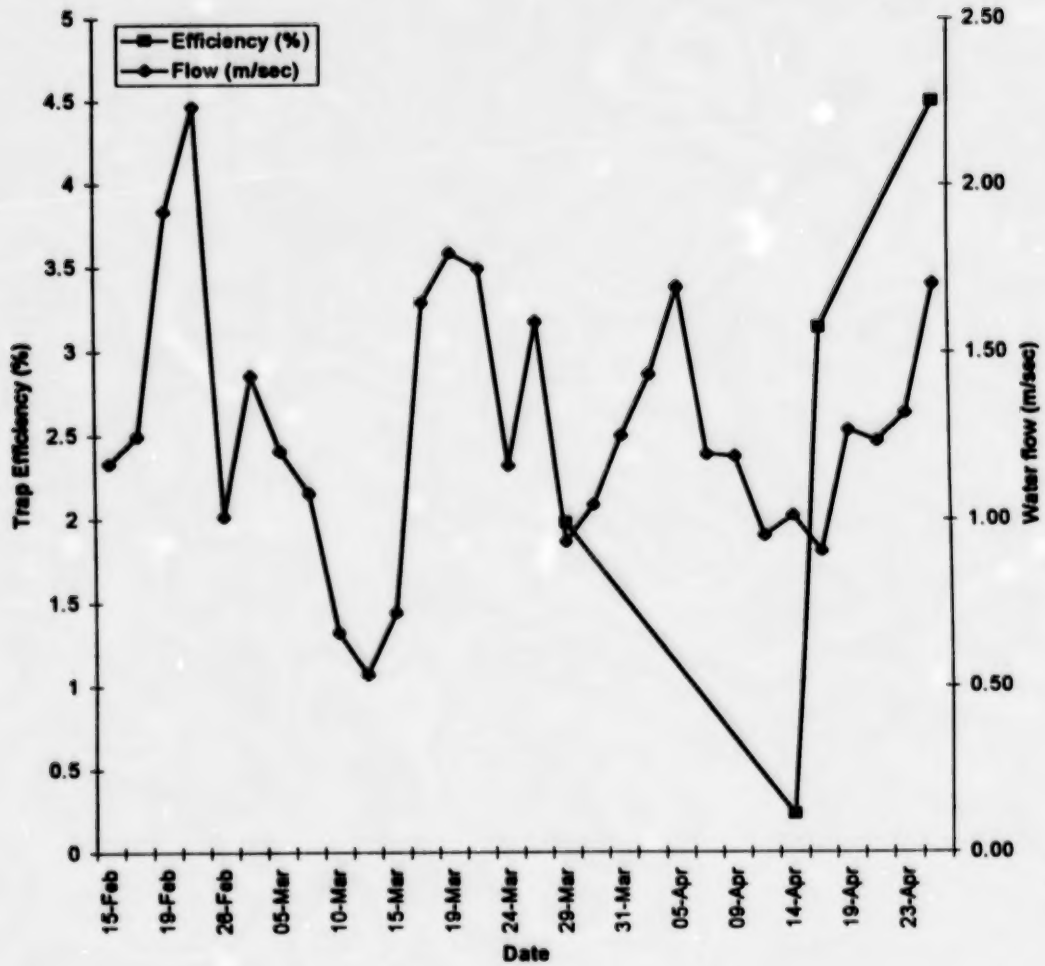
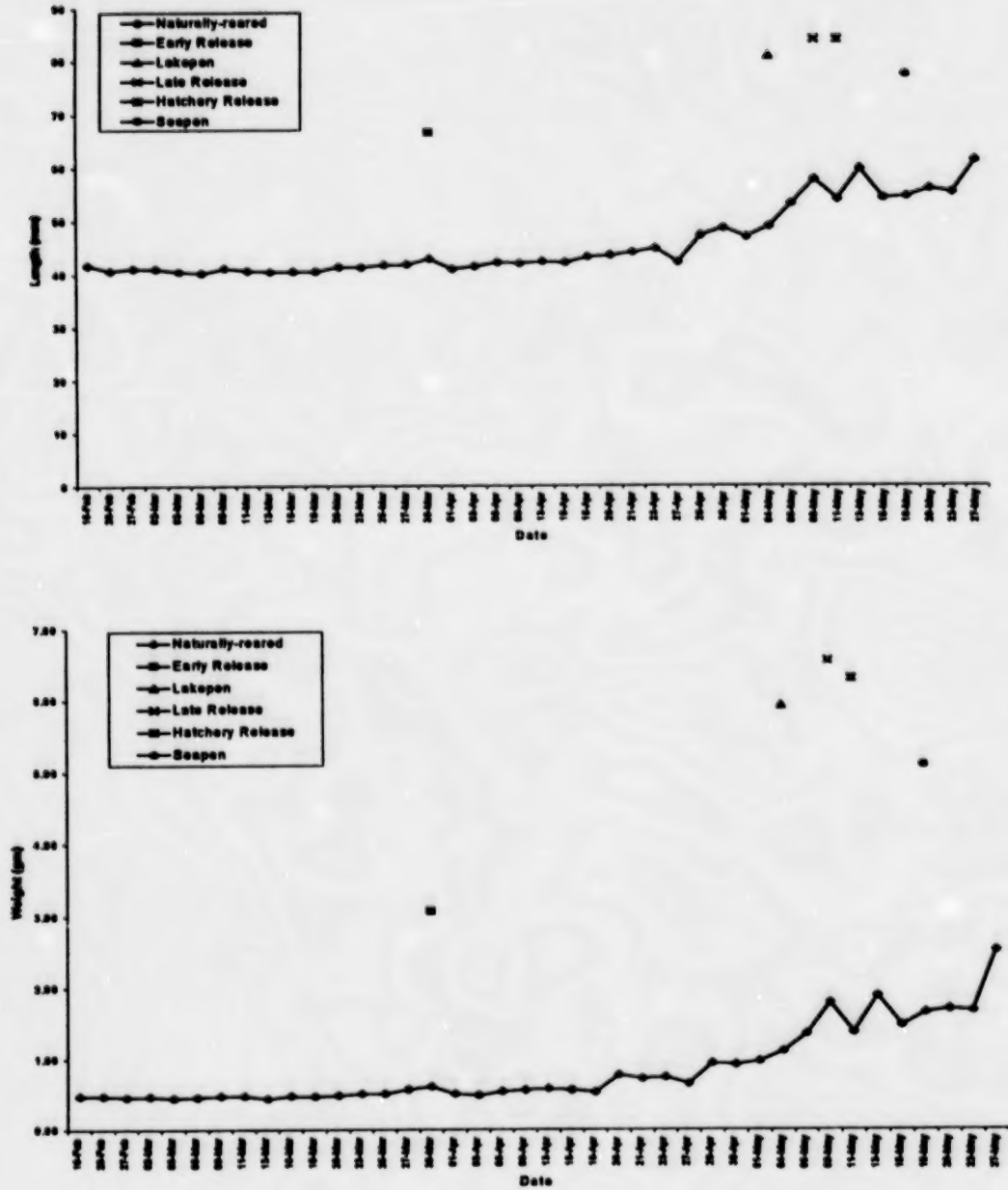


Fig. 3. Daily abundance estimates of natural and hatchery chinook fry downstream migration, pumphouse site, 1999.



* Data points 1 (29-Mar), 3 (16-Apr), 4 (26-Apr) on the Efficiency (%) series, are chum efficiencies, and point 2 (14-Apr) is the chinook efficiency.

Fig. 4. Rotary trap efficiency compared with water flow at the pumphouse site, Cowichan River, 1999.



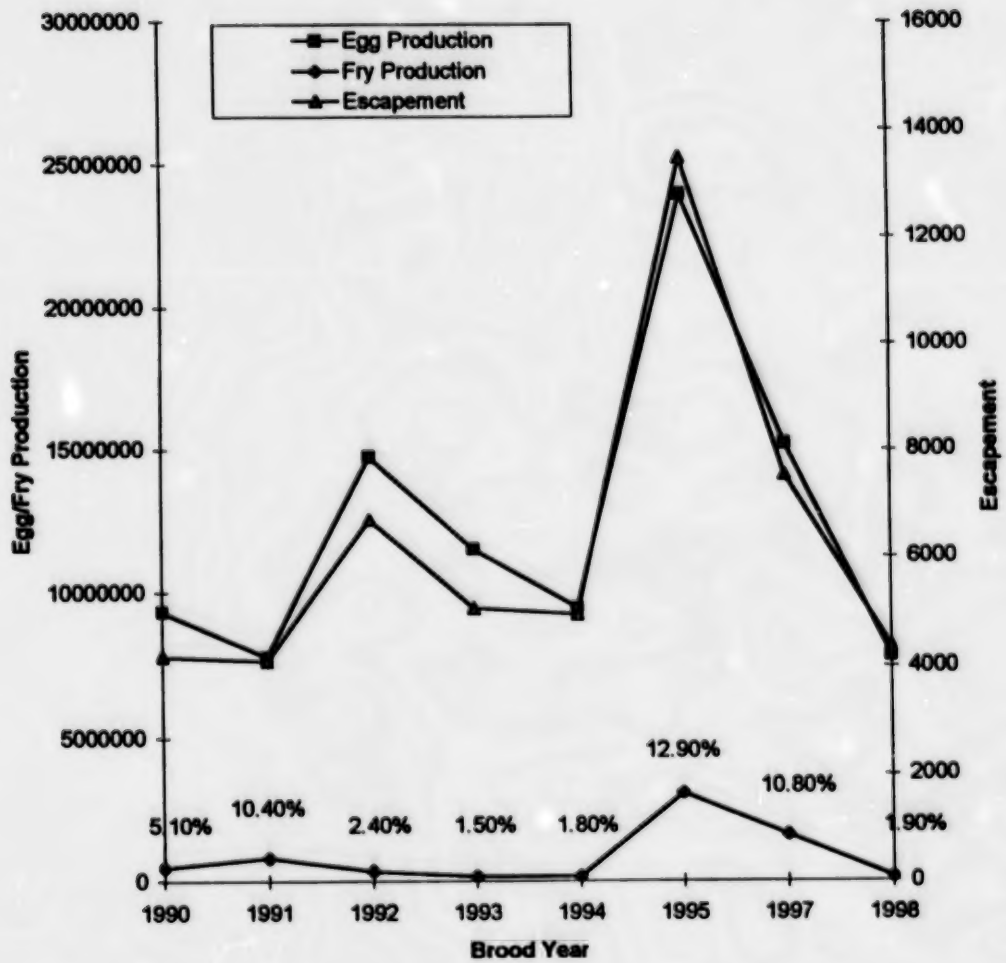


Fig. 6. Egg to fry survival estimates (in brackets) compared to adult escapement and fry production, Cowichan River.

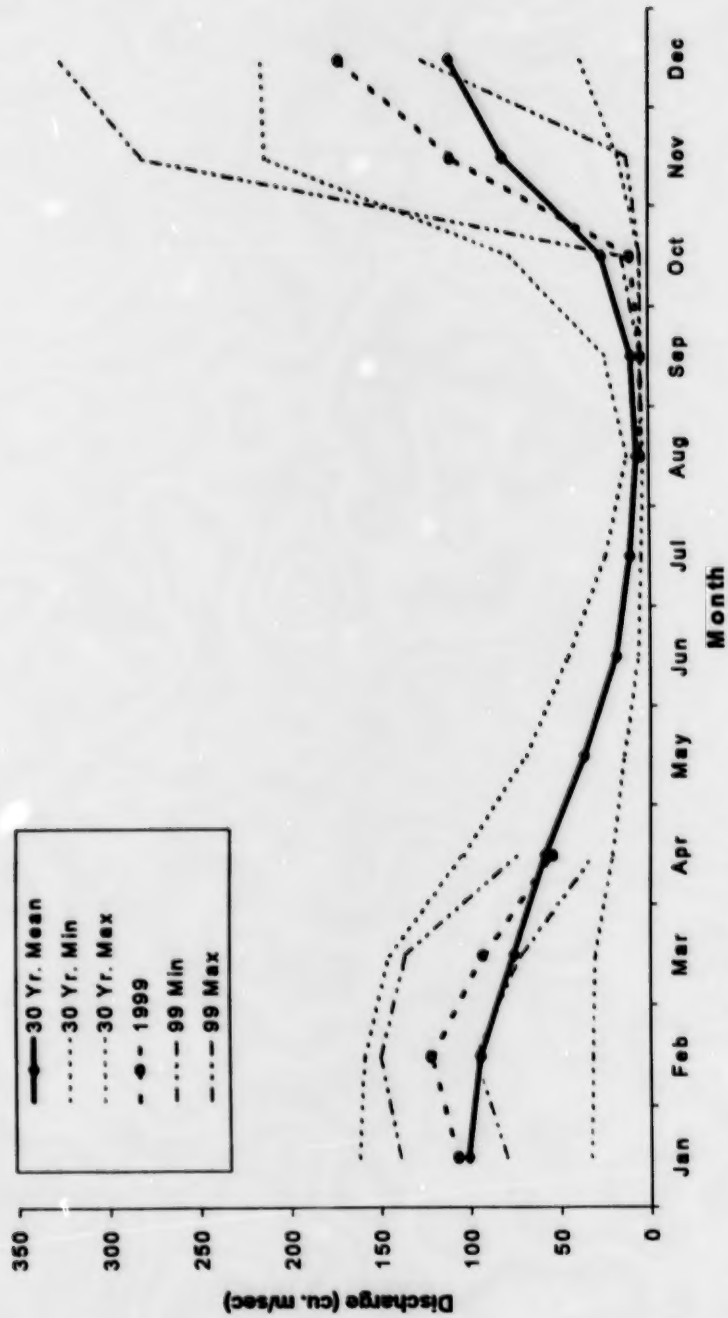


Fig. 7. 1999 Cowichan River discharge (cu. m/sec) compared with 30 year mean.

Appendix 1 (cont'd)

Date	09-Mar	11-Mar	13-Mar	16-Mar	18-Mar	20-Mar
	Lgth (mm)	Wt (gm)	Lgth (mm)	Wt (gm)	Lgth (mm)	Wt (gm)
	40	46	40	46	40	45
	43	53	42	47	42	48
	43	56	40	38	40	43
	42	43	38	37	39	39
	42	52	41	50	37	35
	41	46	42	48	40	44
	40	50	38	41	37	35
	44	54	41	40	42	55
	41	44	39	44	43	49
	43	47	40	47	44	53
	43	51	40	46	42	48
	42	51	41	46	38	46
	43	55	37	29	40	44
	43	54	44	56	43	58
	41	50	42	51	39	44
	42	50	39	36	43	59
	39	38	44	35	41	45
	44	63	42	55	40	49
	41	48	45	76	44	57
	37	35	41	56	39	34
	41	45	37	28	42	54
	40	41	42	47	40	46
	42	53	43	56	39	38
	40	45	38	40	42	55
	41	54	40	54	38	41
	39	45	43	36	36	42
	37	30	40	58	44	57
	41	49	39	57	43	57
			41	37	43	59
			42	44	40	42
Mean length:	41.25	40.77	40.60	44.13	40.65	41.47
Mean weight:	48.14	47.83	47.69	49.03		

Appendix 1 (cont'd)

Date	23-Mar	25-Mar	27-Mar	30-Mar	01-Apr	03-Apr
	Lgth (mm)	Wt (gm)	Lgth (mm)	Wt (gm)	Lgth (mm)	Wt (gm)
	39	46	42	52	42	61
	41	49	40	43	42	69
	39	40	43	55	43	90
	40	50	43	52	40	46
	41	50	44	60	43	64
	42	53	41	53	42	49
	41	50	43	57	41	51
	40	43	39	43	42	58
	44	61	43	53	42	66
	41	50	45	60	42	56
	41	52	40	45	39	71
	41	49	42	48	44	54
	41	50	43	58	49	103
	42	53	43	57	44	65
	39	37	40	43	39	58
	40	52	40	43	42	68
	41	52	40	45	39	44
	39	38	40	46	43	64
	42	52	41	49	41	56
	41	46	40	43	44	63
	44	59	44	59	42	57
	41	45	42	49	42	58
	42	52	42	57	41	49
	42	46	41	45	43	60
	40	45	44	61	44	57
	43	57	41	45	40	53
	40	48	46	72	43	64
	41	50	40	44	41	51
	44	68	40	38	43	63
	49	100	44	58	40	49
Mean length:	41.37	51.43	41.87	51.10	41.97	57.27
Mean weight:			43.00	60.87	41.10	41.53
						50.80
						49.03

Date	06-Apr			08-Apr			13-Apr			15-Apr			16-Apr			20-Apr		
	Lgth (mm)	Wt (gm)	Lgth (mm)	Lgth (mm)	Wt (gm)	Lgth (mm)	Lgth (mm)	Wt (gm)	Lgth (mm)	Lgth (mm)	Wt (gm)	Lgth (mm)	Lgth (mm)	Wt (gm)	Lgth (mm)	Lgth (mm)	Wt (gm)	
	42	53	41	48	40	46	43	69	43	43	57	44	44	70				
	43	62	41	49	42	57	46	72	37	37	39	47	37	91				
	43	59	43	53	42	55	43	51	55	44	53	43	44	74				
	43	52	41	48	45	70	43	67	70	42	54	43	42	86				
	41	50	43	53	42	55	41	55	41	40	48	47	40	97				
	42	56	43	62	38	49	41	54	42	42	53	50	42	132				
	40	45	45	73	40	50	47	85	41	41	49	43	41	71				
	42	55	42	52	42	57	42	52	43	43	44	44	44	81				
	43	62	40	48	42	51	42	51	43	43	57	39	42	56				
	42	50	43	59	44	58	41	58	42	42	56	42	42	69				
	44	59	44	65	41	48	40	52	45	45	58	47	45	80				
	43	58	43	64	41	47	40	51	42	42	63	41	41	58				
	43	56	41	53	44	69	42	49	45	45	68	41	45	54				
	41	52	41	52	42	56	45	68	37	37	26	42	42	78				
	48	82	41	46	42	49	43	68	41	41	46	48	48	104				
	43	63	44	59	43	64	38	26	40	40	48	43	43	65				
	44	57	40	46	43	52	41	54	58	58	43	42	58	67				
	43	58	39	47	43	54	41	52	53	53	47	41	41	74				
	42	49	42	52	49	60	47	51	47	47	77	39	39	59				
	41	47	42	57	43	62	40	50	42	42	56	43	43	80				
	44	51	43	66	44	63	44	52	44	44	58	43	43	69				
	38	40	43	56	46	77	40	50	45	45	61	40	40	53				
	43	50	42	60	45	68	44	65	42	42	52	46	46	87				
	43	54	42	62	42	55	44	58	45	45	60	48	48	89				
	43	55	43	59	43	68	42	44	44	40	42	44	44	70				
	40	43	42	66	39	41	39	53										
	43	67	44	63	43	67	40	58										
	40	47	44	57	43	67	42	53										

Mean length:
Mean weight:

Mean weight:

Appendix 1 (cont'd)

Date	21-Apr	23-Apr	27-Apr	29-Apr	30-Apr	01-May
	Lgth (mm)	Wt (gm)	Lgth (mm)	Wt (gm)	Lgth (mm)	Wt (gm)
	43	56	41	49	48	99
	52	143	45	89	43	60
	45	78	47	97	46	70
	43	64	48	107	38	45
	42	59	44	61	41	74
	43	56	44	71	40	52
	43	68	46	75	42	64
	52	139	43	62	42	59
	44	59	44	59	41	61
	52	130	43	62		
	42	54	45	67		
	44	69	46	82		
	42	64	47	81		
	45	81				
	49	108				
	45	70				
	44	63				
	40	55				
	40	49				
	45	67				
	40	54				
	48	99				
	40	46				
	44	62				
	39	44				
	43	58				
	44	68				
	44	62				
Mean length:	44.18	72.32	44.85	74.00	42.33	64.89
Mean weight:					47.33	94.00
					48.67	92.00
						47.00
						96.80

Appendix 1 (cont'd)

Date	04-May	06-May	08-May	11-May	13-May	15-May						
	Lgth (mm)	Wt (gm)	Lgth (mm)	Wt (gm)	Lgth (mm)	Wt (gm)						
	46	87	63	202	52	151	41	50	67	272	69	306
	57	162	53	143	55	143	48	87	58	180	67	249
	59	216	54	129	64	229	47	89	65	214	47	102
	65	240	43	68	60	193	56	149	67	219	66	216
	57	174					58	158	63	187	56	167
	46	79					58	156	67	231	49	101
	46	89					56	151	56	163	52	115
	46	82					60	197	52	123	45	78
	40	58					62	201	66	259	50	120
	54	143							61	184	44	65
	49	108							70	260	52	118
	45	85							41	66		
	43	66							54	170		
	45	70							62	220		
	43	59							56	167		
	42	52							51	115		
									45	85		
Mean length:	48.94								54.00	59.75	54.27	
Mean weight:	110.63								179.00	137.56	189.38	148.82

Appendix 1 (cont'd)

Date	18-May		20-May		22-May		27-May	
	Lgth (mm)	Wt (gm)	Lgth (mm)	Wt (gm)	Lgth (mm)	Wt (gm)	Lgth (mm)	Wt (gm)
	54	161	55	163	56	180	60	232
	60	223	53	137	59	208	61	237
	53	198	61	221	58	200	64	271
	59	192	52	134	53	133	62	261
	47	106	59	194	60	214	60	263
	56	189			57	184		
	56	159			52	129		
	52	126			50	112		
	53	123			52	131		
	52	129			60	216		
	57	208			52	141		
	57	174						
	48	117						
	60	211						
	48	118						
	59	255						
	60	211						
	57	191						
	56	165						
	59	186						
	57	175						
	61	218						
	58	198						
	52	126						
	46	95						
	41	62						
Mean length:	54.54		56.00		55.36		61.40	
Mean weight:	166.00		169.80		168.00		252.80	

Appendix Table 2. Biosampling data of hatchery-reared chinook, 1999.

Date		31-Mar-99				5-May-99			
		Lgth(mm)	Lgth(mm)	Wt(g)	Wt(g)	Lgth(mm)	Lgth(mm)	Wt(g)	Wt(g)
		76	64	4.86	2.53	90	91	8.36	8.47
		72	60	3.82	1.89	90	72	8.66	3.64
		66	67	2.96	3.19	78	73	5.20	3.82
		66	69	2.91	3.01	85	85	6.59	6.42
		69	65	3.35	2.79	86	83	6.94	6.02
		68	67	3.07	3.31	65	84	2.92	7.02
		62	63	2.28	2.45	82	86	5.86	7.9
		68	64	3.14	2.76	73	88	3.70	7.05
		68	60	3.16	2.23	74	77	4.10	5.88
		64	56	2.63	1.79	75	80	4.75	5.38
		76	65	4.89	2.67	81	78	5.82	5.38
		69	68	3.53	3.55	72	72	3.76	4.01
		63	70	2.50	3.67	78	82	5.24	6.39
		63	64	2.56	2.57	79	80	5.02	5.29
		70	69	3.50	3.28	76	79	4.85	4.96
		55	69	1.40	3.49	77	80	5.77	5.64
		61	72	2.05	4.14	85	80	6.22	5.46
		62	77	2.36	5.02	82	89	6.03	7.52
		68	73	3.17	4.17	85	85	7.44	6.55
		69	60	3.54	1.95	86	83	7.33	6.43
		65	70	2.86	3.41	88	82	7.78	6.41
		65	71	2.94	3.72	78	84	5.21	6.35
		73	70	3.75	3.86	83	80	6.22	5.47
		68	68	2.91	3.2	89	80	7.77	5.14
		63	63	2.14	2.62	82	82	5.70	6.79
Mean length		66.66				80.76			
min		56				65			
max		77				91			
Mean weight				3.07				5.93	
min				1.40				2.92	
max				5.02				8.66	

Appendix Table 2 (cont'd)

Date	10-May-99				10-May-99			
	Lgth(mm)	Lgth(mm)	Wt(g)	Wt(g)	Lgth(mm)	Lgth(mm)	Wt(g)	Wt(g)
	95	88	9.01	6.89	87	85	7.53	6.80
	88	69	7.51	3.58	88	87	7.11	7.82
	88	73	7.45	3.95	92	82	9.25	6.36
	78	73	5.18	3.84	80	84	5.84	5.80
	81	95	5.58	10.10	82	79	5.16	5.09
	88	90	6.98	7.74	78	82	4.67	5.55
	83	84	5.92	6.17	90	73	7.77	4.06
	94	93	8.90	8.53	77	75	4.70	8.24
	80	96	5.40	9.53	97	71	9.90	3.19
	85	69	6.94	2.84	89	90	8.23	8.23
	73	87	4.03	6.78	78	93	5.01	8.68
	81	88	5.52	7.19	88	90	7.31	7.38
	85	100	6.43	11.18	98	93	9.51	8.54
	71	108	3.31	14.26	79	93	4.81	7.87
	91	89	7.72	7.65	75	84	4.59	5.98
	81	85	5.69	6.22	75	84	4.14	6.44
	71	75	3.65	4.69	91	85	8.45	6.25
	81	92	5.34	8.66	83	77	6.59	4.74
	76	76	4.06	4.90	80	81	5.24	5.26
	81	90	5.64	7.77	89	83	7.88	6.04
	78	100	5.12	11.12	95	84	9.00	6.48
	91	74	7.90	4.02	83	85	6.03	6.60
	83	77	6.09	6.80	78	77	4.77	4.00
	92	76	8.60	6.93	83	76	6.12	3.85
	70	82	3.09	5.83	88	75	6.99	3.69
Mean length	83.88				83.82			
min	69				71			
max	108				98			
Mean weight			6.56				6.31	
min			2.84				3.19	
max			14.26				9.90	

Appendix Table 2 (cont'd)

Date 17-May-99			
		Lgth(mm)	Wt(g)
	78	5.18	
	88	8.17	
	76	4.32	
	93	8.79	
	96	7.31	
	92	9.24	
	85	7.76	
	74	4.88	
	77	4.43	
	73	3.94	
	73	3.99	
	72	3.59	
	70	3.43	
	73	3.64	
	91	8.19	
	69	3.21	
	71	3.95	
	85	7.53	
	76	4.23	
	73	4.22	
	70	2.87	
	67	2.73	
	74	3.91	
	78	4.98	
	67	2.94	
Mean length	77.24		
min	67		
max	93		
Mean weight		5.10	
min		2.73	
max		9.24	